CAMPING AND ITS RELATIONSHIP TO FOREST SOIL AND VEGETATION PROPERTIES IN SOUTH CAROLINA

DEPARTMENT OF FORESTRY
FOREST RESEARCH SERIES
NO. 34
SEPTEMBER, 1980

CLEMSON UNIVERSITY
COLLEGE OF
FOREST AND RECREATION RESOURCES
CLEMSON, SOUTH CAROLINA

ACKNOWLEDGEMENTS

The authors gratefully acknowledges the assistance of Raymond M. Sisk, Director; Joe F. Watson, Chief Naturalist; and the Park Superintendents of the Division of Parks, South Carolina Department of Parks, Recreation, and Tourism.

ABSTRACT

As multiple-use forest management becomes more complex, planning on the basis of land capability for each benefit will assume a greater importance. Camping is one of the multiple-use benefits produced by the forest which requires a land allocation, expensive establishment costs, and annual allotments for maintenance. If camping facilities are incorrectly located, quality becomes expensive to maintain, and user satisfaction decreases. By understanding the limitations and effects of sustained camping use, forest areas can be developed and managed according to their capabilities.

The objectives of the study were to assess the effects of camping on forest sites, to identify the factors most important in user site preference, and to delineate the soil properties associated with camping site tolerance. The study found that camping adversely modifies the soil and vegetation characteristics of forest sites. The variables most severely modified were soil bulk density, soil moisture content, penetrability, thickness of the litter and A horizons, infiltration rate, exposed roots, ground cover, and woody regeneration. Two variables, distance to sanitary facility and distance to recreational water, were found to be significant in user site preference. In the final phase of the study, the soil properties of forest sites which were least affected by camping use were identified.

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INTRODUCTION

Camping is one of the most important recreational uses of the forests in South Carolina. It is an activity that is characterized by sustained, concentrated use which results in deterioration of soil and vegetation properties. This deterioration is a major problem for forest managers, for it reduces the quality of the recreational experience and results in higher maintenance costs. Camping use of the State's forests has doubled since 1970 (29), and as more people utilize these environments for recreation, greater management problems can be expected to occur.

Forests move through complex successional stages which result from interacting ecological processes; and as they are utilized for camping, these processes are modified. Forest site modification resulting from camping use has been noted in a number of studies. In Minnesota, Merriam et al. (24) found that areas used for camping were compacted and eroded, and trees were subject to windthrow. Lutz (20), working in Connecticut, found that pore volume, air capacity, and infiltration rates were reduced on camping sites. In North Carolina and Tennessee, Ripley (26) found that increased camping use was directly related to reductions in the hydrologic condition of the soil, texture of the B horizon was associated with changes in the thickness of the A horizon, and soil particle size decreased. Dotzenko (10), working in Colorado, found intensive camping use increased soil compaction, decreased water infiltration rates, and reduced ground cover. A reduction occurred in the number and species of soil-dwelling collembola with intensive use on camping and picnic sites investigated by Mahoney (23) in the Roosevelt National Forest in Colorado.

Little information is available on the effects of camping in South Carolina and on factors related to the selection of sites which best maintain their natural character and are the most desirable to users. This study was undertaken to enhance knowledge in these areas and to provide forest managers with information for use in their recreation planning and management programs. The objectives of the study were to assess the effects of camping on forest sites, to identify the factors most important in user site preference, and to delineate the soil properties associated with camping site tolerance.

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METHODS

South Carolina is composed of four physiographic regions: the Blue Ridge, Southern Piedmont, Carolina-Georgia Sandhills-Southern Coastal Plains, and the Atlantic Coast Flatwoods (11) (Figure 1). These regions were used as the study area.

The Blue Ridge or Mountain region is located in the northwestern corner of the State and ranges from 1,400 to 3,400 feet in elevation. The topography is generally steep to very steep with narrow, rounded ridgetops that are sloping to strongly sloping. The parent material is chiefly schistose and gneissic that is heavily metamorphosed. The soils range from moderately deep to shallow and are classified in the mesic temperature class (mean annual soil temperature [MAST] 57°F). The climate is temperate with an average annual precipitation of 60 to 76 inches. Vegetation in the area is classified as Appalachian oak forest and is composed of oak (*Quercus*), hickory (*Carya*), and shortleaf (*Pinus echinata*) and white (*Pinus strobus*) pine.

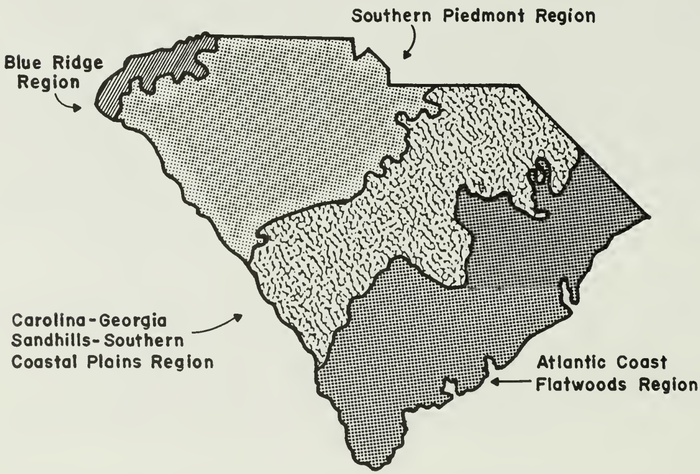

Figure 1. South Carolina land resource regions.

The Southern Piedmont or Piedmont region ranges in elevation from 300 to 1,400 feet, and the topography is characterized by broad and gentle to steep slopes. The parent material of the region is composed of granite, metamorphic slates, gneisses, and schists; and annual rainfall ranges from 45 to 60 inches. The soils are of the thermic temperature class (MAST 60°F) and are deep to moderately deep, well drained friable to firm with sandy loam surface layers and sandy clay loam to clay subsoils. Oak-hickory-pine forest covers the region, with loblolly (*Pinus taeda*) and shortleaf pine, oak, hickory, and yellow-poplar (*Liriodendron tulipifera*) being the dominant species.

The Carolina-Georgia Sandhills-Southern Coastal Plain or Sandhills region ranges from 100 to 600 feet in elevation and is level to rolling with a two to fifteen percent grade on slopes and ridges. The soils are in the thermic temperature class (MAST 61°F) and are moderately fertile and characteristically low in organic matter. The forest cover is composed of longleaf (*Pinus palustris*), loblolly, and shortleaf pine; oak; hickory; and swamp and bottomland hardwoods.

The Atlantic Coast Flatwoods or Coastal region ranges in elevation from sea level to 100 feet. The region contains moderately well to poorly drained soils with loamy sand to clay subsoils that occupy broad flats and depressions. Soils are acid and are classified as thermic (MAST 61°F). The forest cover is a combination of oak-hickory-pine and is composed of longleaf, loblolly, and shortleaf pines; oak-hickory; and swamp and bottomland hardwoods.

Test and control plots were established in twenty-eight South Carolina state parks, and park selection was made on the basis of distribution within a physiographic region (Table 1). In each selected park, site construction dates and attendance records were reviewed to determine the oldest as well as the most and least frequently used campsites. Once this was completed, recreation effects were analyzed in two phases. In the first phase, the oldest camping sites that have been in heavy, continuous use were identified as test plots, and a representative sample of two to three parks was selected from each region. In each of these selected parks, a campsite test plot and a control plot were identified. The control plot was an undisturbed natural area in proximity to the test plot where soil and vegetation characteristics matched those of the test plot.

The center of each 0.025 hectare test plot was established at the observable center of recreational activity. Using this center as a reference point, markers were established along the four cardinal directions, and from these markers soil samples were taken. To assess the degree of soil and site modifications resulting from recreational use, the variables of bulk density; penetrability; moisture percent; water infiltration; thickness of the litter and A and B horizons; pH; concentration of phosphorus, potassium, calcium, and magnesium; texture; number of exposed surface roots; basal area; tree height and diameter; aspect; and slope were measured.

Bulk density was measured by use of a bulk density core extractor which removed a volume of 285 cubic centimeters of soil for each sample. Samples were oven dried in the laboratory, weighed, and bulk

Table 1. Region, number of units, and characteristics of tested campgrounds.

Campground	Region	Number of Units	Elevation (m)	Precipitation (10 yr.avg.)	Temperature (10 yr.avg.) (max.-min.)	Soil Type	Forest Cover
Aiken	Sandhills	25	85	44.0	76 - 53	Lakeland sand	Blackjack, post, and turkey oak, longleaf pine
Andrew Jackson	Piedmont	25	177	45.7	73 - 51	Cecil clay loam	Oak, hickory, shortleaf and loblolly pine
Baker Creek	Piedmont	150	120	47.5	73 - 50	Cataula sandy loam	Oak, hickory, shortleaf and loblolly pine
Barnwell	Sandhills	25	76	44.6	76 - 53	Fuquay sand	Longleaf, slash, and loblolly pine, scrub oak, oak, hickory
Cheraw	Sandhills	25	34	46.0	75 - 49	Lakeland sand	Longleaf and loblolly pine, scrub oak, oak
Chester	Piedmont	45	150	45.6	73 - 51	Wilkes sandy loam	Oak, hickory, shortleaf and loblolly pine
Colleton	Coastal	25	25	47.3	76 - 53	Norfolk loamy fine sand	Longleaf, slash, and loblolly pine, oak, gum, cypress
Croft	Piedmont	50	190	45.8	71 - 51	Cataula clay loam	Oak, hickory, shortleaf and Virginia pine
Edisto Beach	Coastal	75	6	49.1	76 - 54	Crevasse-Dawhoo complex	Live oak, oak, cabbage palm, slash, longleaf, loblolly, and sand pine, wax myrtle
Givhans Ferry	Coastal	25	18	47.3	76 - 53	Norfolk loamy fine sand	Slash,longleaf, and loblolly pine, oak, gum, cypress
Greenwood	Piedmont	157	143	47.5	73 - 50	Enon sandy loam	Oak, hickory, loblolly and shortleaf pine
Hamilton Branch	Piedmont	200	112	47.5	73 - 50	George-ville silt loam	Oak, hickory, loblolly and shortleaf pine
Hickory Knob	Piedmont	75	125	47.5	73 - 50	Cataula sandy loam	Oak, hickory, loblolly and shortleaf pine
Hunting Island	Coastal	200	2	49.1	76 - 55	Fripp-Baratari complex	Cabbage palm, slash and loblolly pine, live and water oak
Huntington Beach	Coastal	128	3	49.1	76 - 54	Chipley	Live oak, longleaf pine

Table 1. Region, number of units, and characteristics of tested campgrounds (continued).

Campground	Region	Number of Units	Elevation (m)	Precipitation (10 yr.avg.)	Temperature (10 yr.avg.) (max.-min.)	Soil Type	Forest Cover
Kings Mountain	Piedmont	125	244	46.7	74 - 50	Tatum silt loam	Oak, hickory, shortleaf and loblolly pine
Lee	Sandhills	50	50	43.7	75 - 51	Lakeland sand terrace	Longleaf, slash, and loblolly pine, oak, gum
Little Peedee	Sandhills	50	30	46.1	74 - 49	Lakeland sand	Loblolly and longleaf pine, oak
Myrtle Beach	Coastal	300	5	49.1	76 - 54	Leon fine sand	Longleaf and slash pine, water oak
Oconee	Mountain	140	530	59.6	71 - 39	Hayesville and Cecil fine sandy loam	Oak, hickory, shortleaf, white, and Virginia pine
Paris Mountain	Mountain	50	430	48.4	71 - 52	Cecil sandy loam	Oak, hickory, shortleaf, white, and Virginia pine
Pleasant Ridge	Mountain	25	366	48.4	71 - 52	Brevard-Evard complex	Oak, hickory, shortleaf, Virginia, and white pine
Poinsett	Sandhills	50	65	44.5	77 - 52	Red bay sandy loam	Loblolly and longleaf pine, oak, cypress, gum, hickory
Rivers Bridge	Coastal	25	33	44.6	76 - 53	Eustis loamy sand	Loblolly, slash, and longleaf pine, bottomland hardwoods
Sadlers Creek	Piedmont	100	215	45.8	72 - 50	Madison sandy loam	Oak, hickory, shortleaf, Virginia, and loblolly pine
Santee	Sandhills	150	40	44.5	77 - 52	Norfolk loamy sand	Oak, hickory, cypress, sweet-gum, loblolly and longleaf pine
Sesqui-centennial	Sandhills	87	87	46.1	74 - 49	Fuquay sand	Oak, hickory, loblolly and longleaf pine
Table Rock	Mountain	109	402	54.7	73 - 49	Grover fine sandy loam	Oak, hickory, shortleaf, Virginia, and white pine

density comparisons were made. Penetrability was measured by using a model CN-973 cone penetrometer and was assessed on the basis of soil resistance to penetration. Moisture percent samples were collected with a bucket auger, sealed in soil tins, weighed, oven dried at 105°C for 24 hours and reweighed. The difference in the two weights was expressed as a percentage of original weight. Water infiltration measurements were taken by driving a concentric metal cylinder five centimeters into the ground and measuring the absorption time in minutes of 1000 milliliters of water. Thickness of the litter and A and B horizons was determined by using a soil probe and by measuring the depth of each horizon. Soil samples were collected with a bucket auger for pH and nutrient analysis by the Soil Testing Laboratory at Clemson University. Soil texture was determined by the Bouyoucos Hydrometer Method (3). Number of exposed roots was determined by using a one-meter square frame randomly placed at the base of each tree ten inches or greater DBH, and by counting the number of exposed roots. Tree height and diameter were measured with an alidade and diameter tape, aspect with a hand compass, and slope with an Abney level. Basal areas were determined from tree diameters.

The statistical analysis of the data employed the SAS (27), systems of MEANS, ANOVA, BARTLETT, and STEPWISE to calculate means and variances, univariate analysis of variance, and test of homogeneity of variance. A logarithmic transformation was applied to several variables in order to comply with the analysis of variance assumption of homogeneity of variance; these variables included penetrability, moisture percentage, and thickness of horizons. A ten percent level of significance was chosen as the criteria for acceptance (Table 2). Based upon this assessment, those parameters that best distinguished the effects of camping use were identified and used as the basis for the second phase. Five variables were utilized to test the degree of pairing between the test and control plots. The lack of significant differences between the variables of basal area, slope, tree height and diameter, and aspect indicated control plots were statistically similar to test plots.

The second phase of the analysis consisted of establishing test and control plots in all twenty-eight parks. Analysis was based on twelve sample sets, each composed of a heavily used site, a lightly used site, and a control, established in each region. Based upon the results of the first phase, the soil variables used in the assessment were bulk density, moisture percent, penetrability, thickness of the litter and A horizons, and water infiltration. These variables were measured by using the previously discussed procedures. Three vegetation factors, number of exposed surface roots, percent ground cover, and amount of woody regeneration, were also assessed as to degree of modification. A one-meter square frame was used to determine percentage of cover and amount of regeneration.

In order to assess the site characteristics which relate to user site preference, the variables of percent crown cover, basal area, degree of screening, distance to nearest neighboring site, distance to nearest sanitary facility, distance to nearest recreational water, and slope were measured. Percent crown cover was determined by photographing the canopy three meters from plot center along each cardinal direction and at plot center. A transparent dot grid was utilized to

Table 2. Comparison of test and control means by Analysis of Variance F tests.

Variable	Mean: Test	Mean: Control
Bulk Density (g/cm^3)	1.45***	0.85
Penetrability (kg/cm^2)	18.2***	3.0
Soil Moisture (%)	11.79***	28.02
Infiltration Rate (cm/min)	0.54***	32.39
Thickness of Litter Layer (cm)	0.1***	2.2
Thickness of A Horizon (cm)	1.8***	4.1
Thickness of B Horizon (cm)	4.4	4.9
pH	5.8*	4.6
Phosphorus (ppm)	6 *	2
Potassium (ppm)	36	36
Calcium (ppm)	555 *	333
Magnesium (ppm)	36	39
Sand (%)	71.6	71.7
Silt (%)	20.9	21.8
Clay (%)	7.7	6.5
Number Exposed Surface Roots (no/m^2)	5.9***	0.6
Basal Area (m^2/plot)	0.51	0.50
Tree height (m)	16.8	17.9
Tree diameter (cm)	24.8	24.0
Aspect	1	1
Slope (%)	4	7

***Significant at 0.01 level.

*Significant at 0.10 level.

compute percent crown cover. Basal area was determined by tree diameter calculations, and degree of screening by use of a pantallometer (25). Distance to neighboring site, sanitary facility, and recreational water was taped, and slope was determined with an Abney level. Analysis of variance was utilized to determine which variables were related to frequency of use. The Duncan's Multiple Range Test was employed to separate means at the 0.05 alpha level.

The final phase of the study consisted of identifying the variables which best reflected the degree of modification resulting from camping use and of determining for each variable the correlation coefficient for the heavily used and control plots. From this assessment those soil properties associated with sites that were least affected by camping use were identified for each region.

RESULTS AND DISCUSSION

The study found that soil and vegetation variables were modified by camping use. When forest sites were utilized for camping, the volume and duration of use resulted in structural soil changes which in combination with trampling affected vegetation (5, 31). The primary adverse effect of camping was increased soil compaction, a problem noted by other investigators (10, 19, 20, 22, 26, 30). Compaction was assessed by bulk density, penetrability, soil moisture percent, and water infiltration (4). One of the major impacts resulting from the compacted condition of the soil was the effects of erosion, which were measured by the variables, thickness of the litter layer and thickness of the A horizon. Table 3 lists the statewide means and standard errors for each tested variable, and Table 4 lists the same data for each of the four land resource regions.

On the control plots, bulk density was consistently lower than on the lightly used plots. This finding indicated that even light, infrequent use of forest environments for camping resulted in soil property alteration. It was also found, except for the Sandhills, that there was a significant difference between bulk density means for the heavily and lightly used sites; this indicated that as sites were exposed to greater volumes of use for longer durations, their bulk density increased.

Bulk density on the control plots was found to increase in each successive land resource region progressing from the mountains. The increase in bulk density on lightly used plots was significantly less in the mountains than in the other regions. Significant increases in bulk density occurred with heavy use in all regions except the Sandhills where the soils are composed of deep, unconsolidated sands.

Penetrability varied with use intensity on a statewide basis, and analysis showed a highly significant difference between treatment means. Averaged for the State, the 5.3 kg/cm^2 of pressure for control plots was considerably less than the heavily used plot mean of 24.7 kg/cm^2. The Coastal region was the only region that did not show this relationship. A significant change occurred with light use, but little detectable change occurred with heavy use. This result is

Table 3. Statewide comparison of test and control plot means and standard errors for soil variables.

Variable	Use Level					
	Heavy		Light		Control	
	Mean	Standard error	Mean	Standard error	Mean	Standard error
Bulk Density (g/cm^3)	1.41**	0.01	1.36**	0.01	1.06	0.01
Soil Moisture (%)	13.18**	0.44	15.01**	0.40	16.86	0.50
Penetrability (kg/cm^2)	24.7**	0.7	18.1**	0.5	5.3	0.2
Thickness of Litter Layer (cm)	0.2**	0.0	0.6**	0.0	2.8	0.1
Thickness of A Horizon (cm)	1.8**	0.2	2.7**	0.2	6.7	0.2
Infiltration Rate (cm/min)	0.58**	0.01	0.73**	0.01	4.83	0.32

**Significant at 0.05 level.

contributed to the high portion of sand that composes the soils of the region.

Soil moisture percent was found to significantly decrease on test plots. Heavily used plots averaged 13.18 percent while control plots averaged 16.86 percent. On a statewide basis, the greatest difference in moisture levels between test and control plots occurred in the Mountain and Piedmont regions. Increased compaction decreased pore space and water retention capacity. The soils of the Sandhills and Coastal regions, however, contained large pores, and the control plots were found to drain rapidly and retain little moisture. Camping use of these soils was found to reduce the large pore structure and to create capillary sized pores which were more likely to retain moisture.

The results of the study regarding bulk density, penetrability, and moisture percentage were also reflected in infiltration rates which were higher on control plots across the State than on test plots. Infiltration rates of heavily used sites decreased significantly when compared to lightly used sites. Infiltration was also an important factor in erosion, for decreasing infiltration leads to increased surface runoff. In the Piedmont region, infiltration was found to decrease dramatically with light use, but only in the Sandhills region did a further significant decrease result from heavy use.

Soil compaction resulting from recreational use has been found to adversely affect sites in many ways. Brady (4) reported that in compacted soils, poor aeration could cause aerobic bacteria to function improperly. In this situation, the anaerobic bacteria would continue to exist and to produce forms of iron and manganese which would possibly be toxic to plants. It has been found that the lack of proper aeration also resulted in decreased root growth, nutrient absorption, and water availability. The number of soil dwelling collembola was found by Mahoney (23) to decrease on forest sites used for recreation. This decrease contributed to reductions in porosity and aeration. The rejuvenation potential of the soil could be seriously affected by reductions of microorganism populations since these organisms mix, granulate, and decompose organic matter (4). Harley (14) reports that mycorrhizal fungi, invaluable in nutrient uptake and water absorption for plants, could be adversely affected by lowered concentration of oxygen in the soil.

Studies by Ripley (26), Helgath (15), Magill and Nord (21), and Settergren and Cole (28) also noted the relationship between compaction and the effects of erosion. In this study, the effects of erosion were measured by the loss of the litter layer and the thickness of the A horizon. There was a significant difference in the thickness of the litter and A horizons between the test and control plots on a statewide basis. Thickness of the litter layer on control sites was highest in the Piedmont region and decreased by significant amounts in the Sandhills, Mountain, and Coastal regions, respectively. Litter thickness on test plots was greatest in the Sandhills region. In all regions, significant decreases in litter layer thickness accompanied light use, and further reductions occurred with heavy use in the Sandhills and Coastal regions. Light use in the Piedmont and Mountain regions so reduced the litter layer that there was no

Table 4. Comparison of test and control soil variable means and standard errors among use levels for each region.

Variable	Use Level: Heavy Mean	Heavy Standard error	Light Mean	Light Standard error	Control Mean	Control Standard error
Blue Ridge						
Bulk Density (g/cm^3)	1.34**	0.02	1.28**	0.02	0.90	0.02
Soil Moisture (%)	19.74**	1.00	22.55**	0.78	24.74	0.70
Penetrability (kg/cm^2)	31.3**	1.4	20.8**	0.9	6.6	0.3
Thickness of Litter Layer (cm)	0.2	0.0	0.5**	0.1	2.7	0.2
Thickness of A Horizon (cm)	1.6	0.2	2.3**	0.3	6.4	0.3
Infiltration Rate (cm/min)	0.56	0.02	0.73**	0.05	8.45	0.97
Southern Piedmont						
Bulk Density (g/cm^3)	1.47**	0.02	1.37**	0.02	1.01	0.02
Soil Moisture (%)	15.26**	0.87	17.16**	0.83	22.76	1.07
Penetrability (kg/cm^2)	32.1**	1.3	21.9**	1.1	7.6	0.4
Thickness of Litter Layer (cm)	0.1	0.0	0.3**	0.1	4.1	0.2
Thickness of A Horizon (cm)	0.4**	0.1	1.0**	0.2	7.1	0.3
Infiltration Rate (cm/min)	0.41	0.01	0.50**	0.01	5.17	0.27
Carolina-Georgia Sandhills-Southern Coastal Plain						
Bulk Density (g/cm^3)	1.34	0.02	1.39**	0.02	1.11	0.02
Soil Moisture (%)	9.61	0.64	9.22	0.40	9.07	0.49
Penetrability (kg/cm^2)	25.6	1.4	19.7**	1.2	4.0	0.2
Thickness of Litter Layer (cm)	0.5**	0.1	1.1**	0.1	3.4	0.3
Thickness of A Horizon (cm)	3.0**	0.4	4.2**	0.5	9.1	0.5
Infiltration Rate (cm/min)	0.56**	0.01	0.82**	0.03	4.82	0.43
Atlantic Coastal Flatwoods						
Bulk Density (g/cm^3)	1.48**	0.02	1.40**	0.02	1.23	0.02
Soil Moisture (%)	8.09**	0.51	11.11	0.61	10.82	0.93
Penetrability (kg/cm^2)	9.7	0.8	9.9**	0.7	3.0	0.2
Thickness of Litter Layer (cm)	0.1**	0.0	0.4**	0.1	0.8	0.1
Thickness of A Horizon (cm)	2.3**	0.5	3.2	0.5	3.8	0.6
Infiltration Rate (cm/min)	1.08	0.04	1.15**	0.04	3.24	0.64

**Significant at 0.05 level.

significant difference between lightly and heavily used plots.

Like the thickness of the litter layer, the A horizon thickness was least modified on the Coastal region control plots. Light use had little effect on the A horizon thickness in this region, while significant losses occurred with the same level of use in all other regions, especially in the Sandhills. Because of topography, the severity of erosion was reduced in the Coastal region. The loss of the litter and A horizon adversely affected forest camping sites, for these horizons are the zones where organic matter was incorporated into the soil. Kittredge (17) reported that the loss of the litter layer may have accelerated the effect on erosion, since it was the layer which provided soil protection. Kittredge also cited a study by Billings showing that moisture retention capability of soil decreased with decreasing thickness of the litter layer and decreasing amounts of organic matter. This has also been one of the factors that contributed to the highly significant decrease in soil moisture content on recreation sites.

The vegetation on forest camping sites was found to have been adversely affected in two ways by use. The first resulted from tramping and physical abuse, and the second from soil compaction and the effects of erosion. Three variables were measured to assess effects on vegetation; these were number of exposed roots, percentage of ground cover, and amount of woody regeneration (Table 5). Exposed roots occurred in negligible amounts in the Sandhills and Coastal regions. Statewide, however, surface erosion exposed a significant number of roots on tested plots. The Mountain and Piedmont regions experienced the greatest degree of root exposure, for these areas were more susceptible to erosion. In the Sandhills and Coastal regions, only the heavily used plots showed significant root exposure, and the percentage of ground cover on control plots was similar despite the diverse character of the two regions. A significant decrease in percent ground cover resulted from light use in all but the Coastal region, and additional losses occurred with heavy use in all regions. Test plots in the Coastal region had significantly more ground cover than did test plots in the other regions, and test plots in the Sandhills had the least. The amount of woody regeneration on control plots was lowest in the Coastal region. The amount of regeneration on lightly used plots in all regions was significantly lower than that on control plots, but no detectable decrease resulted from heavy use. The Mountain region test plots at both levels of use displayed significantly higher levels of regeneration than all other regions.

Vegetation on and around camping sites showed adverse effects of recreational use. Deteriorated soil conditions resulted in an unfavorable environment for on-site vegetation. Compaction increased bulk density, thereby, resulting in a restriction of root growth which was followed by the removal of the litter layer by erosion. Decreased pore space meant reduced moisture retention capacity, and droughty periods caused increased stress leading to loss of plant vigor, overstory stag-heading, and mortality. The loss of the litter layer and the A horizon also severely restricted or precluded successful revegetation on used sites and greatly reduced seed germination and seedling survival on heavily used sites (6, 7).

Table 5. Statewide and regional comparison of test and control plot means and standard errors for vegetation variables.

Variable	Use Level					
	Heavy		Light		Control	
	Mean	Standard error	Mean	Standard error	Mean	Standard error
Statewide						
Exposed Roots (no/m^2)	4.42	0.80	3.41**	0.71	0.08	0.04
Ground Cover (%)	14.44**	1.60	22.66**	1.94	35.31	1.76
Woody Regeneration (no/m^2)	3.00	0.76	4.14**	0.66	18.25	1.66
Blue Ridge						
Exposed Roots (no/m^2)	9.58	2.04	9.19**	1.98	0.03	0.03
Ground Cover (%)	16.69	3.06	21.78**	3.28	30.14	3.42
Woody Regeneration (no/m^2)	9.17	2.76	9.19**	1.60	28.47	4.46
Southern Piedmont						
Exposed Roots (no/m^2)	5.72	2.08	4.28**	1.62	0.09	0.09
Ground Cover (%)	11.81	3.27	15.14**	3.19	38.91	3.63
Woody Regeneration (no/m^2)	1.03	0.32	1.31**	0.35	15.24	1.71
Carolina-Georgia Sandhills-Southern Coastal Plain						
Exposed Roots (no/m^2)	1.36**	0.49	0.06	0.06	0.01	0.00
Ground Cover (%)	5.36**	1.68	11.11**	2.61	36.25	3.76
Woody Regeneration (no/m^2)	1.36	0.58	5.00**	1.68	23.42	3.21
Atlantic Coastal Flatwoods						
Exposed Roots (no/m^2)	1.00**	0.38	0.11	0.11	0.22	0.23
Ground Cover (%)	23.89**	3.67	42.61	4.13	36.25	3.26
Woody Regeneration (no/m^2)	0.44	0.20	1.06**	0.55	5.61	1.36

**Significant at 0.05 level.

In order to properly plan for camping use of forest sites, managers should understand not only the soil and the effects on vegetation that result from use, but also the physical site characteristics that affect frequency of use of individual sites. By understanding the physical site characteristics which most influence site choice, the forest manager could better plan and manage sites to meet the needs of users. The variables which were used to assess site preference were percent crown cover; basal area; degree of screening; distance to neighboring site, sanitary facility, and recreational water; slope; and aspect. Results of the analysis have been given in Table 6. Percent crown cover was considered to be an important determinant in site selection (8, 18). However, study means indicated no relationship with site selection. Means for heavy and lightly used plots were similar, and this could be explained by seasonal exposure adjustments by users. Basal area, as a measure of tree density, proved to have no significant effect on site use levels. Degree of screening also showed no detectable difference between use levels, as did slope, aspect, and distance to neighboring sites. The study found that only two variables were significantly correlated to frequency of use, and these variables were distance to sanitary facility and distance to recreational water. The mean distance to a sanitary facility for heavily used plots across the State was 48.62 meters, as opposed to a mean of 59.09 meters for lightly used plots. Attendance records seldom identified the sites that were directly adjacent to a sanitary facility as being among the most heavily used, and only 37 percent of the sites so identified were more than 53 meters away. Conversely, over 60 percent of the lightly used sites were more than 53 meters from these facilities.

The study found that in those parks where campgrounds had been established near bodies of recreational water, there was a tendency for waterfront sites to be the more heavily used. Over half of the sites identified as heavily used were within 30 meters of the water, while only 10 percent of the sites identified as lightly used were within the same distance to water. Of the sites examined which were 30 meters or less from the water, only 17 percent were lightly used, and these were located in parks where sites more distant did not exist. Use level means were 58.3 meters and 136.1 meters for heavily and lightly used plots, respectively.

The last phase of the study concerned the identification of soil properties associated with plots which were least affected by camping use. On the basis of correlation analysis, soil properties were identified for each region (Table 7). For the Mountain region, these soils were well-drained, moderately deep, and composed of weathered granite and gneiss; the surface layer was grayish-brown in color; fertility and permeability were moderate; organic matter content and available water capacity were medium; and infiltration was moderately rapid. In the Piedmont region, soils were well-drained and formed from weathered gneiss and schist; surface layers were brown to red in color; organic matter and fertility were low; infiltration and permeability were moderate; and available water capacity was medium. The Sandhills soils were deep and well-drained; surface layers were gray in color; fertility was medium to high; organic matter, acidity; and available water capacity were medium; and infiltration and permeability were rapid. In the Coastal region, soils were found to be excessively

Table 6. Statewide comparison of test plot means and standard errors for variables influencing user preferences.

Variable	Use Level			
	Heavy		Light	
	Mean	Standard error	Mean	Standard error
Crown Cover (%)	37.07	1.68	35.91	1.77
Basal Area (m^2/plot)	0.67	0.04	0.61	0.04
Screening (%)	40.19	2.34	37.81	2.30
Distance to:				
Neighboring Site (m)	16.65	0.85	16.96	0.95
Sanitary Facility (m)	48.62**	3.87	59.09	3.63
Recreational Water (m)	58.30**	9.14	136.11	21.29
Slope (%)	3.46	0.61	3.02	0.60

**Significant at 0.05 level.

Table 7. Delineation of soil properties by region.

Parent Material	Slope (%)	Depth (cm)	Horizon Depth (cm)	Texture	Available water (cm/cm)	Permeability (cm/min)	Soil pH	Particle Size (%) 2.0 (mm)	Particle Size (%) 0.74 (mm)
Blue Ridge									
residium from granite and gneiss	8	140	0-22	fine sandy loam	0.28	0.31	5.0	95.0	60.0
			22-85	clay loam	0.35	0.16	5.0	95.0	60.0
			85-140	silty clay loam	0.35	0.07	5.0	95.0	42.5
Southern Piedmont									
Mica gneiss and hornblende gneiss	4	90	0-15	clay loam	0.28	0.17	5.7	100	55.0
			15-68	clay	0.45	0.02	5.3	100	75.0
			68-90	clay loam	0.38	0.06	5.5	100	65.0
Carolina-Georgia Sandhills-Southern Coastal Plain									
loamy unconsolidated sediments	1	180	0-42	loamy sand	0.20	0.17	5.5	100	22.5
			42-145	sand clay loam	0.32	0.05	5.0	100	42.5
			145-180	sandy clay	0.32	0.05	5.0	100	47.5
Atlantic Coastal Flatwoods									
unconsolidated loamy sediments	4	150	0-150	fine sand	0.20	0.55	5.3	100	27.5

drained and sandy; the surface layer was grayish-brown in color; infiltration and permeability were rapid; and organic matter, available water capacity, and fertility were low.

The delineated soil properties for each region provide a guide for the forest manager in locating areas for camping development. By equating as closely as possible the soil properties of a proposed site, or by locating areas containing the listed properties, sites most tolerant to camping use can be identified.

SUMMARY AND CONCLUSIONS

As the forest of South Carolina becomes more important to the Nation as a source of multiple-use benefits, greater production will be required. To achieve this increased production, intensive planning incorporating all forest benefits will be undertaken. One benefit in which planning will be conducted is that of providing quality recreational opportunities. This study was undertaken to provide basic information for this planning process, since forest planners and managers must have the data necessary to insure that investments of land, funds, and manpower are properly allocated. Camping is one of the most popular and investment intensive forms of forest recreation. It also is characterized by sustained, concentrated use of forest sites which result in adverse modifications of soil and vegetation properties. In order to plan for this activity, information must be gained on the soil and vegetation modifications that occur, on the site characteristics that are most important to users, and on sites that can best maintain their properties when used for camping.

The study found that camping resulted in modifications of soil and vegetative properties of forest sites. On a statewide basis, camping was found to increase soil bulk density and penetrability, and to decrease thickness of the litter and A horizons, soil moisture content, and water infiltration. A significant reduction occurred in ground cover vegetation and woody plant regeneration, while the number of exposed roots increased. Frequency of use correlated strongest with distance to sanitary facility and distance to recreational water. An analysis of soil property modification identified those properties associated with forest sites that were the least affected by camping use.

Site modification resulting from camping can be managed to lessen adverse effects. Some of these techniques are mulching (13), transplanting of shrubs (7), surfacing with gravel or asphalt (12), seeding with grass (9), irrigation (1), fertilization (16), and enhancing natural vegetation through cultural practices (2). When new camping facilities are planned, the process of selecting sites most tolerant to recreational use can be assisted by using the delineated properties in association with the soil survey report produced by the USDA Soil Conservation Service for the county in which planning is occurring.

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